Lannea microcarpa: A Review of its Medicinal Uses, Phytochemistry and Pharmacological Properties

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Abstract: *Lannea microcarpa* is an important food plant and herbal medicine in West Africa. The present study critically reviewed the medicinal uses, phytochemistry and pharmacological properties of *L. microcarpa*. The keywords including *L. microcarpa*, its synonyms, English common names, medicinal uses, phytochemistry and pharmacological properties were searched using electronic databases such as ISI web of knowledge, ProQuest, science direct, OATD, scopus, Open-thesis, pubmed and google scholar. The search for pre-electronic literature such as conference papers, scientific articles, books, book chapters, dissertations and theses were carried out at the University library. Literature studies revealed that *L. microcarpa* is used as herbal medicine in 58.3% of the countries where the species is indigenous. The major diseases treated by *L. microcarpa* extracts include fever and malaria, gastro-intestinal problems, ulcers and wounds, respiratory problems, pain and musculoskeletal disorder, haemorrhoids, intestinal worms and skin diseases and used as ethnoveterinary medicine. Phytochemical compounds identified from the species include amino acids, anthocyanins, fatty acids, flavonoids, myricetin glycosides, phenolic compounds and triglycerides. Pharmacological studies revealed that *L. microcarpa* extracts have antibacterial, antifungal, antihypertensive, anti-inflammatory, antioxidant, antiprotozoal and antitrypanosomal, inhibition of α-amylase, shea butter stabilization and trypsin inhibition activities. Detailed studies are required aimed at establishing the efficacy, clinical relevance, safety and mechanisms of action of the plant extracts and its compounds.

Keywords: Anacardiaceae, ethnopharmacology, herbal medicine, *Lannea microcarpa,* West Africa.

INTRODUCTION

Lannea microcarpa Engl. & K. Krause is a member of the cashew or Anacardiaceae family. The name of the genus, "*Lannea*" is based on a Latin word "*lana*" which translates to "wool" in reference to young plant parts which are densely hairy or possibly to the wool on the roots of some *Lannea* species [1]. *Lannea microcarpa* is a deciduous tree with dense, semi-spherical crown, which grows up to 16 m in height [2]. The tree is indigenous to Benin, Cameroon, Côte d'Ivore, Gambia, Ghana, Guinea, Mali, Niger, Nigeria, Senegal and Togo. It has been recorded in the savannah biome, common in deep friable soil and rocky soil especially in the Sahel savanna [2]. *Lannea microcarpa* is regarded as a multipurpose tree in West Africa, harvested from the wild to provide food, medicines, fibre, dye, handicrafts, woodcarving and fuel for the local people [2]. Young leaves of *L. microcarpa* leaves are eaten as leafy vegetables [2] and seeds are important sources of edible oil and the oil can be used in animal feeds and cosmetics [3] and biodiesel production [4]. Due to its high use value, *L. microcarpa* is often protected by farmers during land clearing in Benin and Burkina Faso [5,6] and the species is tolerated in agroforestry parklands and also protected in home gardens in northern Bénin [5]. Research by Diop [5] revealed that *L. microcarpa* is the third important indigenous fruit tree in Mali and the species is also ranked as the sixth most valued indigenous fruit tree in Benin [8]. Therefore, the fruits of *L. microcarpa* are traded commercially in Benin [9], Burkina Faso [10] and Nigeria [11] and the different plant parts are sold in informal herbal medicine markets as herbal medicines in Benin [9]. As *L. microcarpa* is mostly collected from the wild, the species population is declining and vulnerable in Burkina Faso [12,13], threatened with extinction in Benin [14] and threatened also in Nigeria mainly because of urbanization, deforestation, expansion of agricultural activities and unsustainable collection [15]. It is within this context that this review was undertaken aimed at summarizing the medicinal uses, phytochemical and pharmacological properties of *L. microcarpa* so as to provide baseline data required for evaluating the therapeutic potential of the species.

Medicinal Uses of *L. microcarpa*

The aerial parts, bark, fruits, gums, leaves, roots, seeds, stem bark and wood ash of *L. microcarpa* are used as herbal medicines against 46 and three human and animal diseases, respectively (Table **1**). The medicinal uses of *L. microcarpa* are recorded in Benin, Burkina Faso, Cameroon, Ghana, Mali, Nigeria and

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ISSN: 2223-3806 / E-ISSN: 1927-5951/18

Table 1: Medicinal Uses of *L. microcarpa*

Medicinal use	Parts of the plant used	Country	References
Abortifacient	Stem bark	Nigeria	[18]
Abscesses	Wood ash	Senegal	[2]
After birth	Bark, fruits, leaves and roots	Benin	[13]
Anaemia	Bark, fruits, leaves and roots	Benin	[13,19]
Bilharzia	Fruits, gums, leaves and seeds	Mali	[16]
Blisters	Bark, fruits, leaves and roots	Nigeria	[2]
Boils, carbuncles and furuncles	Bark, fruits, leaves and roots	Nigeria	[2,20]
Cathartic	Bark, fruits, leaves and roots	Nigeria	[2]
Colic	Aerial parts	Benin	[2]
Respiratory problems (cough, flu and sore throat)	Bark, fruits, leaves and roots	Benin, Burkina Faso and Nigeria	[2,13,21]
Gastro-intestinal problems (constipation, diarrhoea, dysentery and stomach ache)	Bark, fruits, leaves, roots and stem bark	Benin, Burkina Faso, Ghana and Nigeria	[2,13,22-25]
Elephantiasis	Stem bark	Cameroon	[26]
Eye problems	Bark, fruits, leaves and roots	Benin	[13]
Fever and malaria (including brucellosis, paludism and trypanosomosis)	Bark, fruits, leaves, roots and stem bark	Benin, Burkina Faso, Mali and Nigeria	[13,23,25,27-29]
Haemorrhoids	Bark, fruits, leaves, roots and stem bark	Benin and Burkina Faso	[13,23]
Hematuria	Stem bark	Burkina Faso	[24]
Hypertension	Bark	Burkina Faso	[30]
Headache	Bark, fruits, leaves and roots	Benin	[13]
Intestinal worms	Bark, fruits, gums, leaves, roots and seeds	Benin and Mali	[13,16]
Jaundice	Bark	Burkina Faso	[25]
Mental disorder	Leaves and stem bark	Burkina Faso	[23,24]
Menstrual problems	Leaves	Burkina Faso	[24]
Pain and musculoskeletal disorders	Aerial parts, bark, fruits, leaves, roots and stem bark	Benin, Burkina Faso and Nigeria	[2,23]
Premature birth	Bark	Benin	[31]
Prevention of oral diseases and toothache	Leaves	Burkina Faso	[32]
Rickets	Fruits	Burkina Faso	[21]
Scurvy	Fruits	Burkina Faso	[21]
Skin diseases and varicella	Bark, fruits, leaves and roots	Benin and Ghana	[13,22]
Snake bite	Bark, fruits, leaves and roots	Benin	[13]
Suppress appetite	Fruits	Burkina Faso	[33]
Ulcers and wounds	Bark, fruits, leaves and roots	Benin, Ghana, Mali and Nigeria	[2,11,13,34]
Wounds	Leaves and fruits are mixed with dried stem and leaves of *Cissus quadrangularis* L.	Mali	[16]
Ethnoveterinary medicine (brucellosis and trypanosomosis)	Leaves and stem bark	Benin, Burkina Faso and Mali	[27,28,35,36]
Anthelmintic	Leaves mixed with *Boscia senegalensis* (Pers.) Lam. ex Poir. and *Parkia biglobosa* (Jacq.) R. Br. ex G. Don	Burkina Faso	[17]

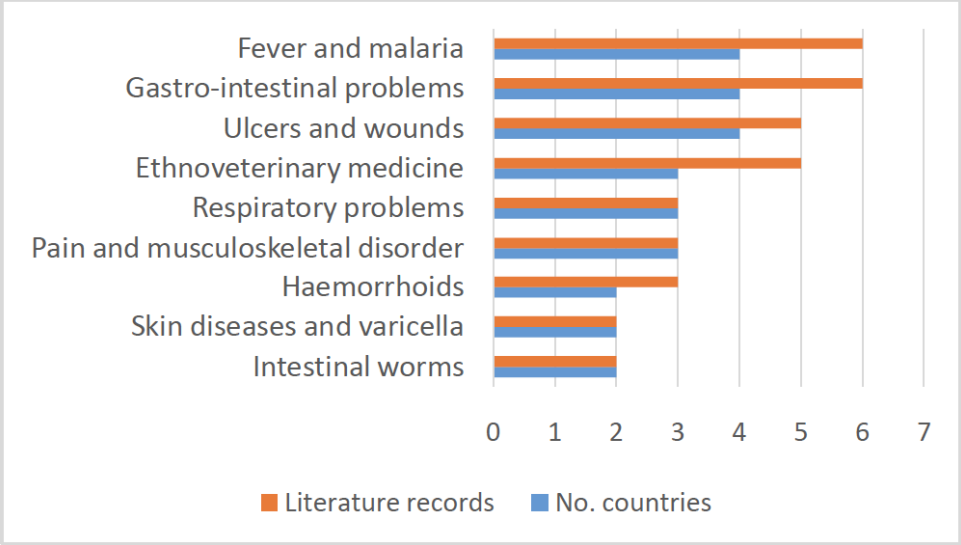

Figure 1: Main medicinal uses of *L. microcarpa*.

Senegal, representing 58.3% of the countries where the species is indigenous (Table **1**). *Lannea microcarpa* is used as herbal medicine against the following major diseases and ailments (in descending order of importance): fever and malaria, gastro-intestinal problems, ulcers and wounds, ethnoveterinary medicine, respiratory problems, pain and musculoskeletal disorder, haemorrhoids, intestinal worms, skin diseases and varicella (Figure **1**). In multi-therapeutic applications, the leaves and fruits of *L. microcarpa* are applied topically on wounds mixed with dried stems and leaves of *Cissus quadrangularis* L. [16] while the leaves of *L. microcarpa* are mixed with those of *Boscia senegalensis* (Pers.) Lam. ex Poir. and *Parkia biglobosa* (Jacq.) R. Br. ex G. Don and used as an anthelmintic [17].

Phytochemistry and Pharmacological Properties of *L. microcarpa*

A variety of phytochemicals and mineral elements have been identified from the the bark, fruit pulp, leaves and seed oil of *L. microcarpa* (Table **2**). Flavonoids and phenolic compounds which enhance the antioxidant capacities of the species have been identified [21,37-39]. Glew *et al*. [40] and Bationo *et al*. [21] identified amino acids, fatty acids, mineral elements and other nutritional components including calcium, carbohydrates, iron, magnesium, manganese, phosphorus and proteins from the fruit pulp and seed oil of the species (Table **2**). Seeds of *L. microcarpa* are characterized by high crude oil and protein content that make them valuable as animal feed or for human nutrition and cosmetics [3,21]. Pale *et al*. [41] identified anthocyanins, cyanidin 3-0-(2-0-β-Dxylopyranosyl) β-D-galactopyranoside and cyanidin 3-0-β-D-galactopyranoside from fruits of L. microcarpa while Picerno *et al*. [42] identified 4'-methoxymyricetin 3-O-α-L-rhamnopyranoside, myricetin 3-O-α-L-rhamnopyranoside, myricetin 3-O-β-D-glucopyranoside, vitexin, isovitexin, gallic acid and epicatechin from leaf extracts of the species.

The pharmacological activities exhibited by *L. microcarpa* extracts include the following: antibacterial [21,38,45], antifungal [45], antihypertensive [46,47], anti-inflammatory [42,48,49], antioxidant [21,37-39,48,50], antiprotozoal and antitrypanosomal [35,51], inhibition of α-amylase [39], shea butter stabilization [39] and trypsin inhibition [39] activities.

Antibacterial Activities

Ouattara et al. [38] evaluated antibacterial activities of ethaonol bark extracts of L. microcarpa against Bacillus subtilus, Enterobacter aerogenes, Enterococcus faecalis, Proteus mirabilis, Pseudomonas aeruginosa, Salmonella enterica, Salmonella typhimurium, Staphylococcus aureus and Staphylococcus camorum using disc diffusion and broth micro dilution methods with ciprofloxacin, erythromycin and tetracyclin as positive controls. The extracts exhibited activities against tested pathogens with 9 mm to 17 mm zone of inhibition, minimum inhibitory concentration (MIC) values ranging from 7.8 µg/mL to 125.0 µg/mL and minimum bactericidal concentration (MBC) values ranging from 31.3 µg/mL to 250.0 µg/mL [38]. Bationo et al. [21] evaluated antibacterial activities of butanol and ethyl acetate fruit and leaf extracts of L. microcarpa against Bacillus cereus, Escherichia coli, Proteus mirabilis, Salmonella typhimurium, Shigella dysenteria and Staphylococcus

Table 2: Nutritional and Phytochemical Composition of the Bark, Fruit Pulp, Leaves and Seed Oil of *L. microcarpa*

Nutritional and phytochemical composition	Value	Plant part	References
Ash (%)	3.1 ± 0.2	Seed oil	[3]
Calcium (µg/g)	6440	Fruit	[40]
Carbohydrates (%)	10.9 ± 1.6	Seed oil	[3]
Iron (µg/g)	16.6	Fruit	[40]
Lipids (%)	64.9 ± 1.3	Seed oil	[3]
Magnesium (µg/g)	2420	Fruit	[40]
Manganese (µg/g)	14.3	Fruit	[40]
Moisture (%)	3.2 - 28	Seed oil	[3,44,45]
Phosphorus (µg/g)	1670	Fruit	[40]
Proteins (%)	21.1 ± 0.3	Seed oil	[3]
Amino acids			
Alanine (mg/g)	2.3	Fruit	[40]
Arginine (mg/g)	2.9	Fruit	[40]
Aspartic acid (mg/g)	3.7	Fruit	[40]
Cysteine (mg/g)	0.9	Fruit	[40]
Glutamic acid (mg/g)	4.4	Fruit	[40]
Glycine (mg/g)	1.6	Fruit	[40]
Histidine (mg/g)	1.0	Fruit	[40]
Isoleucine (mg/g)	1.7	Fruit	[40]
Leucine (mg/g)	2.6	Fruit	[40]
Lysine (mg/g)	1.6	Fruit	[40]
Methionine (mg/g)	0.4	Fruit	[40]
Phenylalanine (mg/g)	1.6	Fruit	[40]
Proline (mg/g)	9.5	Fruit	[40]
Serine (mg/g)	1.7	Fruit	[40]
Threonine (mg/g)	1.6	Fruit	[40]
Tryptophan (mg/g)	3.7	Fruit	[40]
Tyrosine (mg/g)	1.1	Fruit	[40]
Valine (mg/g)	2.1	Fruit	[40]
Fatty acid			
Behenic acid (mg/g)	0.2 ± 0.01	Seed oil	[3]
Eicosanoic acid (mg/g)	0.9 ± 0.03	Seed oil	[3]
Eicosenoic acid (mg/g)	0.3 ± 0.01	Seed oil	[3]
Heptadecanoic acid (mg/g)	0.2 ± 0.0	Seed oil	[3]
Linoleic acid (mg/g)	11.2 ± 0.1	Seed oil	[3]
Linolenic acid (mg/g)	0.4 ± 0.1	Seed oil	[3]
Linoleic acid (mg/g)	0.1	Fruit	[40]
Linolenic acid (mg/g)	0.03	Fruit	[40]
Oleic acid (mg/g)	0.1	Fruit	[40]
Oleic acid (mg/g)	43.5 ± 0.2	Seed oil	[3]
Trans Oleic acid (mg/g)	0.6 ± 0.1	Seed oil	[3]

(Table 2). Continued.

Nutritional and phytochemical composition	Value	Plant part	References
Palmitoleic acid (mg/g)	0.02	Fruit	[40]
Palmitic acid (mg/g)	0.2	Fruit	[40]
Palmitic acid (mg/g)	34.5 ± 0.4	Seed oil	[3]
Stearic acid (mg/g)	8.4 ± 0.2	Seed oil	[3]
Stearic acid (mg/g)	0.04	Fruit	[40]
Triglyceride			
Dilinoleyol olein (%)	2.5 ± 0.03	Seed oil	[3]
Dipalmitoyl linolein (%)	10.9 ± 0.07	Seed oil	[3]
Dipalmitoyl olein (%)	16.5 ± 0.1	Seed oil	[3]
Distearoyl olein (%)	1.5 ± 0.02	Seed oil	[3]
Linoleyol diolein (%)	9.3 ± 0.0	Seed oil	[3]
Palmitoyl dilinolein (%)	5.1 ± 0.3	Seed oil	[3]
Palmitoyl diolein (%)	21.2 ± 0.5	Seed oil	[3]
Palmitoyl linolenoyl olein (%)	1.5 ± 0.02	Seed oil	[3]
Palmitoyl linoleyl olein (%)	12.0 ± 0.3	Seed oil	[3]
Palmitoyl oleoyl stearin (%)	6.5 ± 0.01	Seed oil	[3]
Stearoyl diolein (%)	3.7 ± 0.1	Seed oil	[3]
Stearoyl linoleyl olein (%)	3.0 ± 0.03	Seed oil	[3]
Triolein (%)	6.2 ± 0.3	Seed oil	[3]
Total polyphenol (mg GAE /g dry weight)	1.4 ± 0.05	Seed oil	[3]
α-tecopherol (ppm)	89.4 ± 0.6	Seed oil	[3]
γ-tecopherol (ppm)	437.2 ± 1.7	Seed oil	[3]
δ-tecopherol (ppm)	51.9 ± 0.1	Seed oil	[3]
Total flavonoid content (g quercetin equivalents/100 g of extract)	0.3 – 35.4	Bark, leaves and fruits	[21,37,38]
Total phenolic content (g gallic acid equivalents/100 g of lyophilized extract)	1.2 – 1006.8	Bark, fruits, leaves and seed oil	[21,37,38,39]
Myricetin glycosides			
4'-methoxy-myricetin 3-O-α-L-rhamnopyranoside		Leaves	[42]
Myricetin 3-O-β-D-glucopyranoside		Leaves	[42]
Myricetin 3-O-α-L-rhamnopyranoside		Leaves	[42]
Flavonoid			
Epi-catechin		Leaves	[42]
Trihydroxybenzoic acid			
Gallic acid		Leaves	[42]
Flavone			
Isovitexin		Leaves	[42]
Vitexin		Leaves	[42]
Anthocyanin			
Cyanidin 3-0-(2-0-β-Dxylopyranosyl) β-D-galactopyranoside		Fruits	[41]
Cyanidin 3-0-β-D-galactopyranoside		Fruits	[41]

aureus using disc diffusion and broth micro dilution methods with DMSO as negative control, ampicillin and ciprofloxacin as positive controls. The extracts exhibited activities with inhibition diameter ranging from 7.0 mm to 17.5 mm. The MIC values ranged from 0.2 mg/mL to 10.0 mg/mL [21]. Similarly, Danladi et al. [45] evaluated antibacterial activities of aqueous bark and leaf extracts of L. microcarpa against Pseudomonas syringae using agar well diffusion method. Only leaf extracts were active at 20 mg/ml, 40 mg/ml and 80 mg/ml which exhibited inhibition of 5.5%, 16.7% and 16.7%, respectively [45]. These antibacterial activities exhibited by extracts of L. microcarpa support the traditional usage of the species as remedy for bacterial infections such as abscesses [2], blisters [2], boils [2], carbuncles [20], diarrhoea [9], dysentery [2,9], furuncles [15], prevention of oral diseases [32], skin diseases [22], stomach ache [9,22,23], toothache [32] and wounds [2,9,11,16,32,34].

Antifungal Activities

Danladi *et al*. [45] evaluated antifungal activities of aqueous bark and leaf extracts of *L. microcarpa* against *Aspergillus niger* and *Fusarium oxysporium* using agar impregnation method. Both bark and leaf extracts were active against *Fusarium oxysporium* at 20 mg/ml, 40 mg/ml and 80 mg/ml which exhibited inhibition rate ranging from 11.1% to 33.3%. Only leaf extracts were active against *Aspergillus niger* at 40 mg/ml and 80 mg/ml which exhibited inhibition of 4.4% and 22.2%, respectively [45]. These findings support the traditional use of *L. microcarpa* against fungal and microbial infections such as wounds [2,9,11,16,32,34].

Antihypertensive Activities

Ouedraogo *et al*. [46] evaluated the vasorelaxant and phosphodiesterases inhibition activities of aqueous, dichloromethane and ethyl acetate leaf extracts of *L. microcarpa*. The acculative addition of aqueous extracts caused concentration-dependent relaxation response in both aortas with endothelium-intact and endothelium-denuded aortas and ethyl acetate inhibited phenylephrine-induced vasoconstriction. The extracts were able to inhibit phosphodiesterases and Ouedraogo *et al*. [46] argued that the vascular smooth muscle relaxation properties were due to phosphodiesterases inhibition activities. Similarly, Nitiema *et al*. [47] evaluated hypotensive and preventive activities of aqueous, methylene and ethyl acetate leaf extracts of *L. microcarpa* on anesthetized normotensive blood pressure of Wistar Rat. High blood pressure was induced by adrenaline (75 µg/kg) and phenylephrine (100 µg/kg) administration after administering the extracts. The extracts induced a transient hypotensive effect on normotensive anesthetized rat in dose-dependent manner. On adrenaline and phenylephrine-induced high blood pressure, all extracts caused a dose dependent inhibitory effect by single preventive doses of 0.03 mg/kg to 10 mg/kg when administered 5 minutes before the agonists. The best effects of the extracts tested have been obtained with the crude extract and the ethyl acetate fraction of *L. microcarpa* [47]. These findings corroborate the traditional usage of *L. microcarpa* bark as herbal medicine for hypertension in Burkina Faso [30].

Anti-Inflammatory Activities

Picerno *et al*. [42] evaluated anti-inflammatory activities of leaf extracts of *L. microcarpa* using the inhibition of the croton-oil-induced ear oedema in mice with the non-steroidal anti-inflammatory drug indometacin as control. The extract showed anti-inflammatory activities with infectious dose (ID_{50}) value of 900 μgcm^{-2} which was ten times lower than the ID_{50} value of 93 μgcm^{-2} demonstrated by indomethacin, the non-steroidal anti-inflammatory drug used as reference [42]. Bationo *et al*. [48] evaluated anti-inflammatory activities of crude hydro-acetonic fruit and leaf extracts of *L. microcarpa* using the carrageenan induced paw edema in mice, the inhibitory effects of the extracts on the lipoxygenase, xanthine oxidase and lipid peroxidation. At the doses of 100 mg/kg, 200 mg/kg, 400 mg/kg, the extracts of both the fruit and leaf reduced the carrageenan-induced paw edema while the dose of 200 mg/kg produced a maximum percentage of inhibition of mice paw edema both for fruit (78.4%) and leaf (58.0%) at the fifth hour compared to control. Significant lipoxigenase and xanthine oxidase inhibitory effect was obtained with both fruit and leaf extract. The fruit and leaf extracts inhibited lipid peroxidation with 32.9% and 78.1%, respectively [48]. Similarly, Antwi-Adjei *et al*. [49] evaluated anti-inflammatory activities of aqueous stem bark extract of *L. microcarpa* using the extran sulphate-induced paw oedema in Sprague Dawley rats. The extracts reduced the mean maximal paw oedema in a dose dependent manner when compared to the control. Similarly, the extracts reduced percentage mean oedema in xylene-induced ear oedema in a dose dependent manner when compared to the control [49]. These findings support the use of *L. microcarpa* extracts as herbal medicine against abscesses [2],

blisters [2], boils [2], carbuncles [20], furuncles [20], musculoskeletal disorders [23], pain [2], rheumatism [2] and wounds [2,9,11,16,32,34].

Antioxidant Activities

Lamien-Meda *et al*. [37] evaluated antioxidant activities of acetone and methanol fruit extracts of *L. microcarpa* using the 2,2-dipheny-l-picrylhydrazyl (DPPH), ferric reducing antioxidant capacity (FRAP) and 2,2'-azinobis-3-ethylbenzothiazoline-6-sulphonate (ABTS) assays. The DPPH radical scavenging results ranged from 400 to 3800 mg AEAC/100 g, FRAP (2.5 to 12.5 mmol AEAC/100 g) and ABTS (136 to 230 µmol AEAC/100 g) [37]. Ouattara *et al*. [38] evaluated antioxidant activities of ethanol bark extracts of *L. microcarpa* using the DPPH free radical scavenging assay with gallic acid and quercetin as positive controls. The extract exhibited half maximal inhibitory concentration (IC_{50}) value of 450.3 µg/mL, while the controls, gallic acid and quercetin exhibited much lower IC_{50} values of 0.6 µg/mL and 0.9 µg/mL, respectively [38]. Bationo *et al*. [21] evaluated antioxidant activities of butanol and ethyl acetate fruit and leaf extracts of *L. microcarpa* using the DPPH free radical scavenging assay. Both extracts showed activities with IC_{50} values ranging from 1.6 µg/mL to 46.7 µg/mL [21]. Ajiboye *et al*. [50] evaluated the capability of anthocyanin fruit extract of *L. microcarpa* to scavenge reactive oxygen species and stall aflatoxin B1-mediated oxidative rout on cellular proteins, lipids and DNA using DPPH radical, superoxide anion radical, hydrogen peroxide, hydroxyl radical and ferric ion reducing system assays. The anthocyanins extract at 1.0 mg/mL scavenged DPPH, superoxide ion, hydrogen peroxide, and hydroxyl radical by 91%, 88%, 90% and 83%, respectively, and it also reduced ferric ion. All these results were similar to those demonstrated by vitamin C, used as a reference antioxidant and the reducing effect of the anthocyanin extract on ferric ion was similar to that produced by ascorbic acid used as reference. These results showed that fruit anthocyanins of *L. microcarpa* possess antioxidant properties and halted aflatoxin B1-mediated oxidative rout on cellular proteins, lipids and DNA [50]. Bationo *et al*. [48] evaluated antioxidant activities of crude hydro-acetonic fruit and leaf extracts of *L. microcarpa* by determining the iron reduction by extracts with ascorbic acid as the reference compound. The reducing power exhibited by fruit extracts and its fractions ranged from 0.4 ± 0.0 to 0.8 ± 0.0 mg AAE/100 mg, and 3.8 ± 0.1 to 9.5 ± 0.3 mg AAE/100 mg for leaf extract and its fractions [48]. Hilou *et al*. [39] evaluated antioxidant activities of aqueous, chloroform, ethanol, hexane, methanol and petroleum ether seed extracts of *L. microcarpa* using the DPPH free radical scavenging and FRAP assays with ascorbic acid as the control. The extracts showed activities with IC_{50} values ranging from 1.4 µg/mL to 1375.8 µg/mL against IC_{50} value of 4.0 µg/mL exhibited by ascorbic acid, the control. All the extracts exhibited activities in the reduction of Fe^{4+} to Fe^{2+} with antioxidant activities ranging from 2.7 mg AAE/g to 51.0 mg AAE/g [39].

Antiprotozoal and Antitrypanosomal Activities

Aderbauer *et al*. [35] evaluated antitrypanosomal activities of dichloromethane leaf and stem bark extracts of *L. microcarpa* using the long-term viability assay on *Trypanosoma brucei brucei*. Only leaf extracts showed activities with MIC-values of 200 µg/ml [35]. Similarly, Bello *et al*. [51] evaluated antiprotozoal activities of hexane, chloroform and methanol leaf extracts of *L. microcarpa* using an *in vitro* assay that involved promastigotes and axenic amastigotes of *Leishmania donovani* and *Trypanosoma brucei brucei*. Only methanol extracts exhibited moderate activities with IC_{50} value of 15.2 µg/ml [51]. These results support the traditional usage of leaves and stem bark of *L. microcarpa* as herbal medicine against trypanosomosis [27,35,36].

Inhibition of α-Amylase

Hilou *et al*. [39] evaluated the α-amylase inhibitory activities of ethanol seed extracts of *L. microcarpa* using the dinitrosalicylate assay. The extract showed activities with IC_{50} value of 11.5 mg/mL against IC_{50} value of 0.62 mg/mL exhibited by ascarbose, the control [39].

Shea Butter Stabilization

Hilou *et al*. [39] evaluated shea butter stabilization activities of chloroform, hexane and petroleum ether seed extracts of *L. microcarpa* using the Rancimat method. The extracts decreased the oxidation of endogenous lipids from shea butter with an increase going from 87.5% to 91.5% in the Rancimat induction time shea butter [39].

Trypsin Inhibition

Hilou *et al*. [39] evaluated the trypsin inhibition activities of ethanol seed extracts of *L. microcarpa* using the test of trypsin inhibition as described by Kakade [52]. The extract showed activities with IC50

value of 12.8 mg/mL [39]. The weak trypsin inhibition activities exhibited by *L. microcarpa* extracts imply that the seed extracts of the species may be easily digested by ruminants [39].

CONCLUSION

The present review summarizes the medicinal uses, phytochemistry and pharmacological properties of *L. microcarpa*. Results of this study revealed some research gaps in the phytochemical and pharmacological analyses of the crude extracts of the species as well as compounds identified from the species. There is need to correlate the medicinal uses of the species with the chemical compounds and pharmacological properties of the species. Detailed research on pharmacokinetics, *in vivo* and clinical research involving plant extracts and compounds isolated from the species are required. Future research should also focus on the toxicological properties of the compounds isolated from the species as well as its crude extracts. Since *L. microcarpa* is used in combination with other plant species in various herbal concoctions, it is important to evaluate the synergistic effects of the different extracts and their ability to enhance the efficacy of the additive mixtures.

AUTHORS' CONTRIBUTIONS

I declare that this work was done by the author named in this article.

CONFLICT OF INTEREST

No conflict of interest is associated with this work.

ACKNOWLEDGEMENTS

The author would like to express his gratitude to the National Research Foundation (NRF), South Africa and Govan Mbeki Research and Development Centre (GMRDC), University of Fort Hare for financial support to conduct this study.

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Received on 07-08-2018 Accepted on 17-08-2018 Published on 23-10-2018

DOI: https://doi.org/10.29169/1927-5951.2018.08.04.3